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RICE IRRIGATION IN LOUISIANA

By E. E. Shutts, M. ASCE

IRRIGATION AND IRRIGATION DIVISION

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AMERICAN SOCIETY OF CIVIL ENGINEERS

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PAPERS

RICE IRRIGATION IN LOUISIANA

By E. E. Shutts,[1] M. ASCE

Synopsis

Rice is the principal energy food of the population of the world and is the main staple food for China, India, Japan, Indo-China, Siam, the Dutch East Indies, the Philippines, Malaya, and Madagascar. More than 96% of the world's annual rice crop is produced in the Far East. The principal production countries in the temperate region are Italy, the United States, Spain, Brazil, and Egypt. The consumption of rice in the Far East ranges from 200 lb per capita per year in India, China, Java, and the Philippines to from 300 lb to 400 lb per capita per year in Japan and Siam. The consumption in the United States is only between 5 lb and 6 lb per capita per year.

The culture of rice in all countries is dependent upon irrigation, as approximately 3 tons of water are required to produce 1 lb of rice. The scope of this paper, and of its discussion, is confined to experience with the irrigation of rice in the United States.

History of Rice Culture and Irrigation

Rice ranks among the oldest staple crops in the world. Its cultivation and irrigation probably originated in the area of South India and spread northeastward to China about 3000 B. C. From there rice culture moved through India to Persia, Arabia, Egypt, and ultimately to Europe and the United States. Rice was first produced in the American colonies in 1865, near Charleston, S.C. From North Carolina and Georgia, its production spread to the Mississippi River and Louisana during the Civil War period. By 1890, Louisiana became (and still is) the leading producer of rice. The gradual shift of the rice production areas in the United States from the South Atlantic states to Louisiana, Texas, Arkansas, and California is shown in Table 1. At present,

Note.—Written comments are invited for publication; the last discussion should be submitted by April 1, 1953.

[1] Cons. Civ. Engr., F. Shutts' Sons, Lake Charles, La.

TABLE 1.—RICE PRODUCTION IN THE UNITED STATES,[a] 1839 – 1945 (THOUSANDS OF BUSHELS)

State	1839	1849	1859	1869	1879	1889	1899	1909	1919	1929	1939	1945[a]
Ark.		2	1	3				1,264	7,600	7,956	8,550	14,612
Calif.									9,300	5,719	9,000	14,520
Fla.	17	39	8	14	47	36	81	20	33			
Ga.	445	1,401	1,889	801	913	524	402	139	58			
La.	130	159	228	570	834	2,721	6,213	12,617	19,005	18,832	21,340	23,028
Miss.	28	98	29	13	62	24	27					
N. C.	101	197	273	74	202	210	284	22				
S. C.	2,180	5,753	4,284	1,162	1,873	1,091	1,704	528	131			
Tex.		3	1	2	2	4	259	8,996	6,784	7,027	15,172	18,000
Others[b]	7	93	20	10	29	16	33					
Total	2,908	7,745	6,733	2,649	3,962	4,626	9,003	23,586	42,911	39,534	54,062	70,160

[a] Bureau of the Census, U.S. Dept. of Commerce, except that the statistics for 1945 are estimates of the Bureau of Agri. Economics, U.S. Dept. of Agri. [b] All the remaining states.

the four principal rice producing states in the United States and the acreage and production in barrels (1 barrel equals 162 lb) are as follows:

State	Acres	Barrels
Louisiana	638,516	6,950,282
Texas	524,068	6,762,550
Arkansas	360,064	5,029,716
California	223,385	3,968,173
Total	1,746,033	22,710,721

It is the intent of this paper to deal primarily with the irrigation of rice in the State of Louisiana.

History of Irrigation.—The development of rice as a staple crop has gone hand in hand with the development of irrigation, as it is primarily a water crop. In ancient times, rice was grown in low, flat areas that were irrigated by "providence" methods—that is, by flooding during high water in rivers or impounding either tides or rainfall in low places and later drawing that water on to lower ground for irrigation purposes. Rice was thus grown in the Carolinas by the providence method. High water in streams was impounded by levees. After the rice matured, the water was drawn off for the harvesting of the rice.

After the Civil War, farmers in Louisiana began to consider growing rice on low prairie land in southwest Louisiana and also in southeast Texas—by providence irrigation. In wet seasons this worked fairly well, but dry seasons caused the loss of crops and money invested.

In 1885, J. B. Watkins of the North American Land and Timber Company, working mostly with English capital, attempted a large-scale reclamation and irrigation project using the same general method of the early rice culture in the Carolinas. A 4,000-acre area of coastal marsh on the east bank of Calcasieu Lake, some 30 miles below Lake Charles, was levied off with low levees about 4 ft above the surface of the marsh. The marsh was flat, with a surface elevation of about 1 ft to 1.5 ft above mean low Gulf elevation. Mr. Watkins cut this area east and west with small canals, spaced 0.5 mile apart, using

floating dredges for this work. The water in Calcasieu Lake normally stands at an elevation of about 6 in. above the ground surface, and his idea was to flood this marsh at high tide from the lake, to hold the water on the area with the protection levees, and to pump off prior to the harvest season.

A. Thomson and P. H. Philbrick designed a system of pumps to be used in controlling the water flow. They developed a method for cultivating this marshland by building small steam-driven wench or winding barges, which they placed in the east-west canals. Thus, they plowed the marshland by wenching the plow back and forth across these half-mile strips. They encountered a dry season during which the water for irrigation became salty by infiltration from the Gulf. A very wet autumn, with high water outside the protection levees, and the failure of the primitive drainage pumps, caused the loss of the crop.

In 1898, Mr. Watkins undertook the irrigation of rice on high land prairies with construction of the Farmers Canal. A year later the Louisiana Canal was constructed and is still (1952) in operation. Both canals drew water from the Calcasieu River upstream from Lake Charles. Prior to this time, the Riverside Canal, utilizing water from the Mermentau River in the Crowley rice area, was built.

All of the first canals were wide and shallow, built above the surface of the ground and above the layer of impervious clay hardpan of southwest Louisiana and southeast Texas. The hardpan prevented much loss through seepage. Levees were spaced 100 ft apart and earth used in construction of the levees was taken from borrow pits.

The most westerly part of the rice producing area shown in Fig. 1, and lying between the Calcasieu River and the Sabine River, is irrigated from the Sabine River. The large Sabine canal system and the Krause and Managan irrigation canal serve this area. These canals are considered the safest system, from a salt-water-pollution standpoint, in this entire area, as they draw their waters from the Sabine River, which has a large water shed.

Size of Irrigation Systems.—For many years the rice farmer would cultivate a particular field 1 year and let it lie fallow 1 year. As the fertility of the land was exhausted, it became the practice to farm it 1 year and rest it 2 years. It is now the best practice to farm it 2 years and rest it 3 years; and the 3 years that the land is not farmed are used in planting lespedeza and white dutch clover for grazing beef cattle. By working a combination of rice farming and cattle raising, farmers have been able to increase their revenue tremendously and improve their lands. For this reason, canal systems must be designed large enough to serve several times the actual acreage planted to rice in any 1 year.

The first canals constructed were given very little or no slope leading away from the pumping plants toward the end of the system. Most of these early canals were built with pumping plants on the north end and with their system extending toward the south, following the natural slope of the land. Later, it was discovered that prevailing winds from the south tended to back the water up and prevent its proper movement out through the system. Old canals were largely rebuilt and new canals were given a slope of approximately 0.5 ft per mile to overcome this difficulty.

The irrigation season lasted from 100 to 150 days, after which these canals were allowed to dry out. This practice, and the fact that canals were very shallow, caused dense growth of marsh grass and water weeds to choke the flow of water. It is now the accepted procedure to squeeze in the levees and to dig the channels deep, using material for levees taken from the inside of these canals.

Irrigation waters were originally taken over natural drainage through long wooden flumes—some of the flumes being more than 1,000 ft long. Common practice today is to take natural surface drainage under these canals through concrete boxes or large pipe siphons.

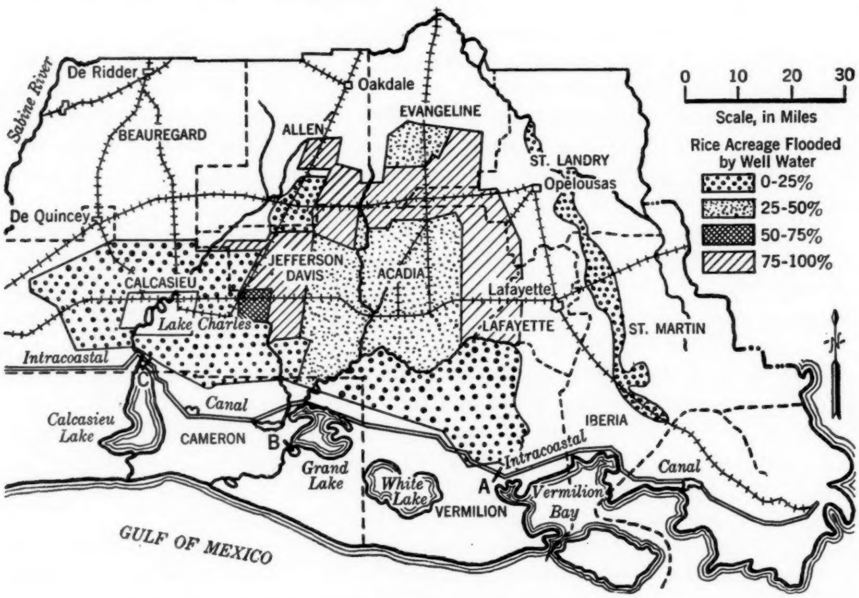

FIG. 1.—SOUTHWESTERN LOUISIANA SHOWING RICE AREA, BY IRRIGATION WATER SOURCE, IN 1947

Irrigation Pumps.—By 1900 sufficient pioneer work had been done in raising irrigated rice crops to indicate the need for larger central pumping plants which could supply water to large acreages. The rice farmers paid for this water either on the basis of acreage water rental or on a share crop basis, thus eliminating the need for individual farmers maintaining a separate small pumping plant. A number of so-called irrigation canal companies were formed and pumping plants of corresponding size were required.

At this time, the centrifugal pump was available as a vertical box type or horizontal pump, built in comparatively small sizes so that pumps of 25,000 gal per min or 30,000 gal per min were considered very large. The vertical pumps at that date were usually unsuited to anything but quite low lifts, and the horizontal pump, equally inefficient, was adapted to higher heads and was made of cast iron.

Several types of large-capacity pumps were tried. At least one triple expansion pumping unit was used and a number of rotary pumps of the conoidal type were installed. The latter pumps were suprisingly efficient and some of them are still in use (1952), but slow speed and costly construction make them uneconomical as compared with the centrifugal pump. The need for large efficient centrifugals prompted the pump manufacturers to improve their product. Pump designers from Europe were imported to design more efficient pumps. By 1910 pumping units as large as 48 in. and with capacities of from 50,000 to 60,000 gal per min each were in use.

The period from 1920 to 1930 saw many important changes. The diesel engine with its superior fuel economy reached the United States and many diesel-driven pumping units were installed. Inasmuch as the speed of all prime movers, including diesel engines, had gradually increased, pumps of higher speed design were a parallel development to permit direct connection.

An equally important development was the general use of electric current. There was a period of great expansion of the electric high lines at this time and the "electric people," needing load, welcomed the large motors needed for these pumping plants, particularly as the pump load came at a season (although only about 100 days duration corresponding to the rice growing season) when the electric loads were low.

Progressive pump manufacturers developed a type of pump impeller combining the characteristics of the centrifugal and axial flow units which resulted in a nearly flat horsepower curve at all pumping heads. Practically all large units built since the late 1920's have had this mixed flow type of impellers.

The history of pumping units since 1930 has been one of steady application of new prime movers combined with increased pump efficiency. Fortunately, the mixed flow unit readily lends itself to higher speeds than previous types.

Because of the widespread availability of cheap gas fuel, most new pumping plants use gas engine drive. These drives have paralleled the development of the gas engine, including the conventional low compression spark ignition engine, the high compression gas diesel and dual fuel diesel engines, and also the latest type of high compression spark ignition engines.

The size of individual units can be increased to whatever the irrigation companies deem necessary. No unit larger than 125,000 gal per min is in actual use as the question of flexibility and dependability indicate the need of multiple units beyond this capacity.

Distribution of Water from Main Canals.—Southwest Louisiana's flat prairie land was cut up into rectangular fields by the building of earth levees approximately 1.5 ft high. These fields were flooded 1 ft deep on one side and only several inches on the high side. Large volumes of water were required for unequal flooding. The method of contour leveeing was then developed and the first levees of this type were constructed on 0.5-ft intervals and were about 1 ft high. The water was led from the main canals through smaller laterals, following in general the crest of the ridges. It was then let out through wooden gates into the high points of the rice field. From here it gravitated down from one field to another through small cuts open in the levees until the entire field was flooded. Better results were obtained from this type of irrigation, and the

interval between contour levees was gradually decreased from 0.5 ft to 0.3 ft, then to 0.25 ft and to 0.2 ft; and, in some instances, these contour levees have been run on as little as 0.15-ft intervals. It is now the general practice to make these levees low and flat, to plow over them, to drill or seed over them, and later to harvest over them.

Much less water is required with the contour levees on smaller intervals. It also has a distinct advantage when one considers the increased use of the airplane in agricultural work. It would be impossible to leave the levees unplanted and unfertilized when planting and fertilizing from the air.

In addition to the marked improvement in the system of leveeing rice for irrigation, since 1951 the farmers have developed a method of land leveling. All of the prairie land in southwest Louisiana is "peppered" with small mounds or knolls spread at close intervals. These knolls are from 1 ft to 3 ft high and constitute a hinderance to irrigation. A method has been developed for removing the soil from the tops of the knolls, grading down the subsoil and replacing the top soil.

Quantities of Water Required for Irrigation

The quantity of rainfall occurring during the growing season, the temperature, and the humidity—all affect the quantity of water required for pumpage. Years ago, when most of the large irrigation systems were designed, the design factor used was for a pump and canal capacity of 10 gal per acre per min. Through the years most of the canal operators found, by actual experience, that the customary pumpage varied from 5 gal per min to 7 gal per min. The modern trend in design is to provide more pump capacity for quicker initial flooding of the fields. A rate as much as 12 gal per acre per min is recommended. Various losses occur in handling irrigation water which affect the volume pumpage required. These principal losses are evaporation and leakage. Until recently no real data were collected on either the supply or the demand of irrigation water in southwest Louisiana. The United States Geological Survey (USGS) and the State of Louisana, Department of Public Works, are now (1952) engaged in an extensive study of this problem. Research has been done by the Rice Experimental Station located at Crowley, La., and preliminary reports are available.

In 1949 the USGS and the State of Louisana determined that the pumpage required on an area of 254,000 acres of rice was 381,000 acre-ft; that is, sufficient water was pumped to flood 254,000 acres approximately 1.5 ft deep. The total acreage irrigated for rice in this area is about 600,000 acres of which 300,000 acres are irrigated from surface water. Fig. 1 shows areas of southwest Louisana irrigated by wells, and Fig. 2 shows the total acreages harvested by years since 1904. The remainder of this acreage is watered from deep wells or from a combination of surface water and ground water. Considerable variations occurred from year to year, and, whereas the year 1949 required 1.5 acre-ft per acre, the year 1948 on the same area required 2.3 acre-ft, and the year 1947 required 1.7 acre-ft. It was determined that the average pumpage used for the irrigation of each deep well in 1949 was 356 acre-ft compared with 598 acre-ft in 1948 and 393 acre-ft in 1947; and 307 acre-ft were produced by

the average well for the year 1946. Where irrigation is done by a combination of surface water and ground water, it is difficult to determine the exact proportion of water used or produced from each source as farmers normally do not keep such records. They naturally use surface water, which is cheaper to pump, as long as possible or until the supply becomes contaminated with salt water, and they then begin to use their wells or reduce the contamination of the surface water by mixing it with well water.

When the rice is young, it is affected by even small amounts of chlorides. It builds up resistance to salt with age and stands more salt in its maturity. Table 2, by B. M. Sturgis, agronomist, gives the commonly accepted tolerance of rice to salt water.

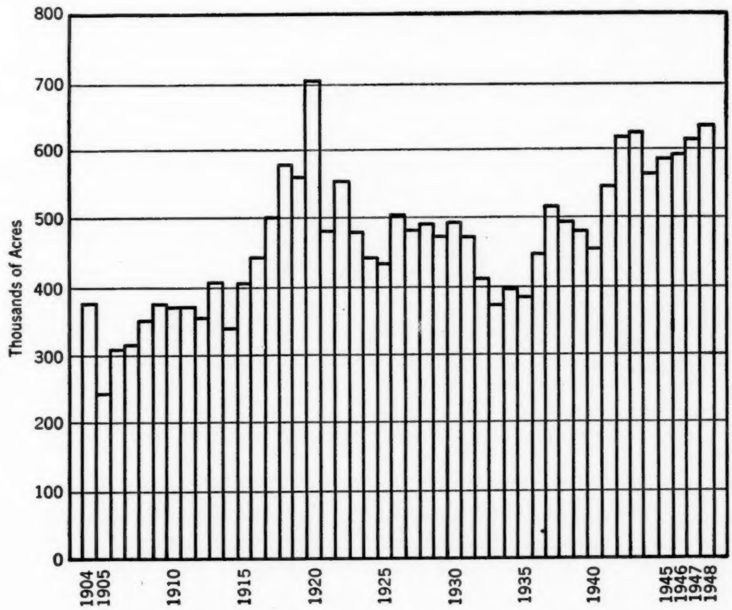

FIG. 2.—TOTAL ACREAGE OF RICE HARVESTED ANNUALLY IN LOUISIANA

Stream Flows and Seasonal Demands for Irrigation.—The State of Louisana has been blessed naturally with one of the highest rainfalls of any state in the union—the average yearly rainfall since 1900 being about 56.4 in. Because of the hot climate, evaporation is also very high. Unfortunately for the rice industry, the maximum rainfall and attendant stream flow do not occur during the irrigation season. In the Calcasieu River at Kinder, La., the USGS has established a gaging station and Fig. 3 is a copy of their hydrographic chart of the Calcasieu River flow at this station during the year 1948-1949. The runoff in the stream at this station reaches a peak of more than 12,000 cu ft per sec on December 1, maintaining a high average until May 1. In the period from June to October the flow is well below 1,000 cu ft per sec and drops to a minimum of 400 cu ft per sec.

TABLE 2.—COMMONLY ACCEPTED TOLERANCE OF RICE TO SALT WATER

Concentration of Salts as NaCl, in Water			Relative Tolerance at Various Stages
Grains[a]	Ppm	Pressure[b]	
35	600	0.50	Tolerable at all stages; not harmful.
75	1,300	1.09	Tolerable from tillering on to heading. Rarely harmful, and only to seedlings after the soil is dry enough to crack.
100	1,700	1.42	Harmful before tillering; tolerable from jointing to heading.
200	3,400	2.84	Harmful before booting; tolerable from booting to heading.
300	5,100	4.27	Harmful to all stages of growth. This concentration stops growth and can only be used at the heading stage when the soil is saturated with fresh water.

[a] Grains per gallon. [b] Osmotic pressure, in atmospheres.

The period of low flow in this stream, which is characteristic of practically all streams in this area, occurs at the same time when the greatest demand is thrown on surface waters for irrigation purposes. The hydrographic chart in Fig. 3 is fairly average of most years.

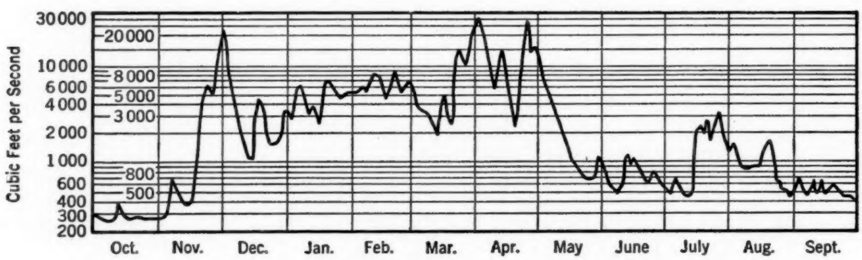

FIG. 3.—HYDROGRAPH FOR CALCASIEU RIVER, NEAR KINDER, LA., 1948–1949

The conclusion to be drawn from the foregoing evidence is that some method of conserving or impounding the stream flow is necessary. It is indeed unfortunate that the topography of southwest Louisana does not lend itself readily to the construction of dams and reservoirs. The terrain is so flat and low that only low heads could be maintained and the vast areas of land would be flooded in any impounding project. For instance, a plan to dam the Calcasieu River has been considered for many years. It is feasible to impound only 25 ft in depth, and if such a dam were constructed, only about 200,000 acre-ft could be impounded.

Salt-Water Menace.—Strange as it may seem, with the high rainfall rate in Louisana, the fresh-water situation for irrigation is becoming critical. The denuding of timber land in the upper areas of the stream basins in the state, the completion of numerous extensive drainage ditches throughout the agricultural areas, and the improvement of the lower reaches of most of the streams for navigation—have all combined to increase runoff during the heavy rainy season. They have also drained the fresh-water coastal marshes, which in the past have acted as fresh-water reservoirs. Most of the coastal streams in Louisana are deep, with large cross-sectional areas and sluggish currents. Normally these streams enter the Gulf through shallow passes. Upstream from these

passes there are usually some large shallow lakes, or some bodies of water, into which the fresh water from the streams flow before entering the Gulf. For example, the Calcasieu River has a depth of from 35 ft to 60 ft, maintaining these depths for some 50 miles above the Gulf. However, 20 miles above the Gulf this river spreads out into Calcasieu Lake with an average depth of less than 4 ft, and a width of from 10 miles to 12 miles. Originally, the pass into the Gulf maintained a depth of about 7 ft. In 1940, a 30-ft channel was dug into this lake and out into the Gulf for deep-sea navigation. The water level in this stream, even 50 miles above the Gulf, normally stands at about 1.5 ft above sea level.

The Mississippi River Commission and the United States Corps of Engineers in their laboratory at Vicksburg, Miss., constructed a model of this river about 250 ft long, and determined that, during normal times, a wedge of salt water from the Gulf moved upstream along the bottom of the channel and river at the same time that fresh water was flowing out over the top of the salt water. The hydraulic grading of these streams is so low that the difference in the specific gravity between the fresh water and the salt water creates this condition. Since the construction of the Lake Charles ship channel to the Gulf, the lower 40 miles of this river has ceased to function as a source of fresh water for rice irrigation.

Plan for Conservation of Surface Water.—Realizing the depletion of the surface fresh-water supplies in Louisana, the Corps of Engineers have constructed a series of three major salt-water locks to stop the inflow of salt water from the Gulf through the intracoastal system (and the natural streams that cross it), and to recharge the large marsh areas between the rice belt and the coast with fresh water.

The first lock on the east, which is at the eastern limit of the rice belt, is what is known as Vermilion Lock (see point A, Fig. 1). The second lock (point B, Fig. 1) is on the Mermentau River at Catfish Lake to control salt water at this point. The third lock (point C, Fig. 1) is at the junction of the intracoastal canal and the Calcasieu River, and keeps the water from flowing west into the Calcasieu River and mingling with the salt water brought in by the Calcasieu ship channel. It also stops the salt water in the ship channel from flowing eastward during the pumping season.

It has also been proposed to construct two or more dams on the upper Calcasieu—one near Kinder and one farther north. A study has also been made of the possibility of constructing skimmer locks or gates across the Calcasieu River and its tributaries above the head of the deep-sea navigation at Lake Charles. These gates or locks would not raise any appreciable head in the river, and the crest of these dams would be sufficiently below the surface to allow small boats to navigate over them. They would allow fresh water to flow over the top but would stop salt-water movement upstream along the bottom.

Ground-Water Sources

The Use of Ground Water for Irrigation.—Nature has provided the State of Louisiana with a bountiful rainfall. She has also provided a large storage

capacity for underground water, found in thick aquifers or water-bearing sands. The location of nine test wells is shown in Fig. 4, and a vertical section through these wells, prepared from electric well survey logs, is shown in Fig. 5. Paul

FIG. 4.—PART OF SOUTHWEST LOUISIANA SHOWING THE POSITION OF THE GEOLOGICAL SECTION IN FIG. 5

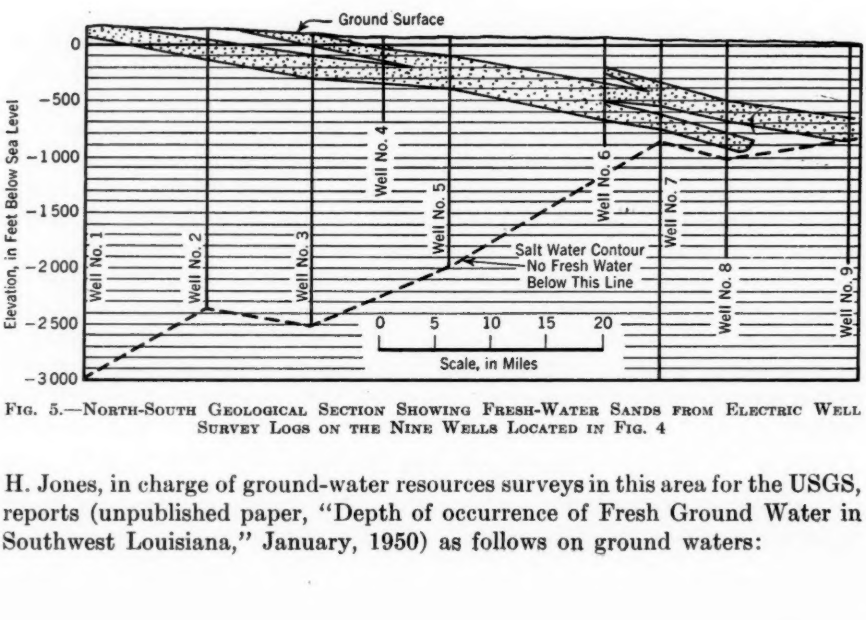

FIG. 5.—NORTH-SOUTH GEOLOGICAL SECTION SHOWING FRESH-WATER SANDS FROM ELECTRIC WELL SURVEY LOGS ON THE NINE WELLS LOCATED IN FIG. 4

H. Jones, in charge of ground-water resources surveys in this area for the USGS, reports (unpublished paper, "Depth of occurrence of Fresh Ground Water in Southwest Louisiana," January, 1950) as follows on ground waters:

"Most fresh ground water originated as precipitation entering the aquifer in the area in which it crops out and percolating through the aquifer in the direction of the hydraulic grading. Salt water, which may have saturated the aquifer at the time of its deposition, or subsequent to it, is flushed from the updip part of the aquifer by recharge and sub-surface flow. Rainfall is evenly distributed by season in the out crop area of the aquifers and ranges from fifty to sixty inches a year. The rate of precipitation generally is in excess of the rate at which the aquifers can transmit the water down the dip under existing hydraulic grading. There is, therefore, throughout the year local ground water discharge (rejected recharge), into the streams that cross the outcrop area."

It would appear from this statement that there would always be an ample supply of ground water for every need in southwest Louisiana. The pollution of the surface streams has now increased the irrigation demands on ground water. The pumpage for rice irrigation in 1949, to irrigate 254,000 acres of rice, was about 281,000 acre-ft. Inasmuch as the demands on ground waters for rice irrigation are seasonal, nature has given an opportunity to recharge the aquifers during the 8-month period in which no pumping is done. Fig. 6 is

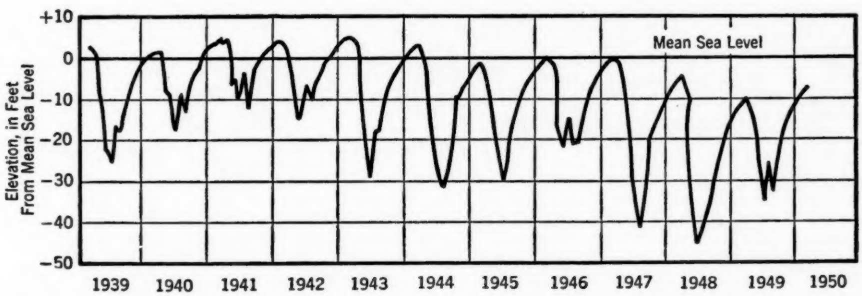

FIG. 6.—FLUCTUATION OF WATER LEVEL IN OBSERVATION WELL TD-9, THREE MILES EAST OF WELCH, LA.

a hydrograph showing the fluctuation of the water level in one well located 3 miles east of Welch, La., and covering an 11-year period. This hydrograph clearly indicates the recovery of the ground-water level when pumping ceases and also shows the maximum pull-down when pumping is in progress. It reflects a gradual lowering in the water level in the aquifers at this point from 4 ft above sea level to 10 ft below sea level after recovery has occurred.

Other Demands on Ground Water.—With the completion of the Port of Lake Charles for deep-sea navigation, a heavy industrial development of this area has occurred. These industries use large quantities of ground water for cooling and other purposes. It is estimated that during the 1949 season, the maximum industrial pumpage of ground water in the Lake Charles area was about 58,000,000 gal per day. This a constant demand and gives no opportunity for recovery of the water level in the aquifers. In the entire area surrounding Lake Charles, there has been a continuous and rapid drop in this water level with no recovery.

Fig. 7 is a map of southwest Louisiana showing the piezometric surface of the water and the pleistocene sands and gravels as of March, 1950. The fresh-water surface in the sands in the vicinity of Lake Charles has been pulled down below 50 ft. At one point in September, 1950, it was reported as low as 70 ft. Deep well pumps in this area are now (1952) being set as low as 120 ft below ground surface.

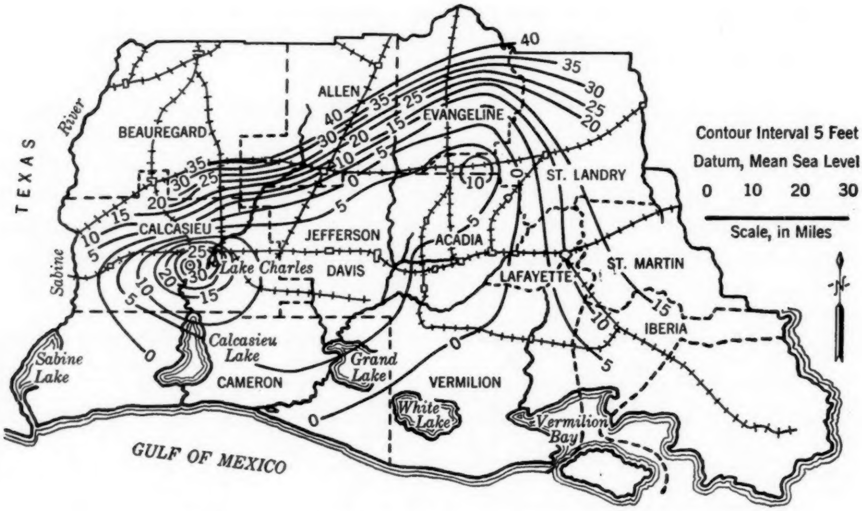

Fig. 7.—Piezometric Surface of Water in Pleistocene Sands and Gravels, Southwestern Louisiana, as of March, 1950

The Department of Public Works of the State of Louisiana, issued the following statement[2]:

> "It is of grave significance that these withdrawals have resulted in an intrusion of salt water from the Gulf into the aquifers. Withdrawals of ground water for irrigation purposes have been of such magnitude and intensity that the ground water elevations along the lower limits of the rice area is lower than Gulf level during the irrigation season. This condition, aggravated by occasional dry periods such as occurred in 1924 and again in 1930, may result in salt water intrusion to the extent that a large portion of the rice producing area will have to be abandoned unless an adequate supply of surface water is made available."

The foregoing statement does not take into consideration the tremendous constant demand on underground waters for heavy industrial uses.

Protection and Conservation of Ground-Water Supplies.—From the statement quoted in the preceding section, and from a study of the piezometric surface of underground water, it is apparent that Southwest Louisiana is in need of some immediate solution of this problem and of an active conservation

[2] "Summary of Improvements Necessary for Navigation; Flood Control; Drainage; Irrigation and Alleviation of Stream Pollution in South West Louisiana," by Dewitt L. Pyburn and Leo M. Odom, Dept. of Public Works, State of Louisiana, May, 1947.

program. It has been suggested that this underground reservoir of fresh water be recharged or supercharged in some manner. The construction of a series of small impounding areas along the outcropping of the aquifers is being studied. Also some method of surcharging is needed, drilling large shallow wells for recharging these aquifers with water that is now allowed to run off as surface water during the rainy season. The lowering of the water levels in these sands from 50 ft to 70 ft below sea level, at a point only 30 miles above the Gulf coast line, creates an interesting question. Will the hydraulic pressure differences between the salt waters in the Gulf and the water pressure in the fresh-water sands now at − 50 ft cause some break-through or leakage back from the Gulf? Mr. Jones has stated that these water-bearing sands must be fairly well sealed off by a bending down of the formations along the coastal shelf and possibly a sealing off of these sands with impervious clay deposited on the Gulf floor.

In addition to the danger expressed in the foregoing paragraph, there is another source of possible pollution of these aquifers. Fig. 5 shows the contour line between salt water and fresh water in the vertical section. This is the point below which no fresh water is found in this area. This salt-water line, as plotted from the electric survey logs, rises rapidly toward the Gulf shore line, and wells drilled along the coast for fresh water are usually found brackish. There exists a grave question concerning the possibility of this underground salt water breaking into the fresh-water aquifer at or near the coast line and flowing northward, thus polluting the area where the heavy agricultural and industrial demand is located.

Conclusion

In his steady progress for betterment and improvement, man has constantly depleted the bountiful resources of nature. Has southwest Louisiana—by denuding its forests, by improving its surface-water runoff through improved drainage, by the construction of deep-sea and barge navigation channel and river improvements for marine traffic, by its successful bid for heavy industrial development, and by its increased agricultural activities—endangered its supply of the most necessary resource for human existence, namely, fresh water?

If this is the fact, man must bestir himself to conserve and to replenish this resource in order to maintain his supply of fresh water and food upon which life is dependent.

Source of Information

The information contained in this paper has been drawn from the following sources and the writer is indebted to these sources for most of the statistics given: The USGS—Mr. Jones, geologist in charge of ground-water investigation, and E. L. Hendricks (A. M. ASCE), hydraulic engineer in charge of surface-water investigation; the Louisiana Department of Conservation; the Department of Public Works; the Louisiana State Rice Experimental Station of which Rufus K. Walker, agronomist, is the director; John Welsh, general manager of the Sabine Canal system; Frank Everett, chief engineer of the

Acadia-Vermilion irrigation system; H. G. Chalkley, president of the North American Land Company; S. Arthur Knapp, manager of Walker Calcasieu Properties; John E. Jackson, county agent, Calcasieu Parish; the Corps of Engineers, from their Hydraulic Experimental Station at Vicksburg; F. Shutts' Sons, Consulting Civil Engineers of Lake Charles; J. Mitchell Jenkins, agronomist and retired superintendent, Rice Experimental Station; and B. S. Nelson, consultant on irrigation pumps.